

Global Climate Change and Its Effects on Human Habitat and Environment in Malaysia

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ABSTRACT

Climate change is the biggest threat to nature and humanity in the 21st century. Climate change means annual temperature of the earth has swung up and down by several degrees Celsius over the past million years. Temperature records in the past 30 to 50 years have shown warming trends in most places including Malaysia. Climate change may bring about an increase in the frequency and intensity of extreme weather events, such as, droughts, storms and floods. The effects of global climate change are many and varied. Climate change is caused by the emission of heat-trapping gases – mostly carbon dioxide (CO₂) – from vehicles, industry, power plants and deforestation. As these gases build up, they act like a thick blanket, overheating the planet, changing our climate, and threatening our health, economy and natural environment. An analysis of temperature records in Malaysia shows a warming trend. For Malaysia, the temperature changes range from +0.7°C to +2.6°C, while precipitation changes range from -30% to +30%. Climate change in Malaysia showed this phenomenon have negative impacts on human habitats such as agriculture, forests, water resources, coastal resources, health and energy sector.

ABSTRAK

Perubahan iklim merupakan ancaman paling besar terhadap alam sekitar dan manusia pada abad ke 21 ini. Perubahan iklim bermaksud suhu tahunan bumi telah meningkat dan jatuh beberapa darjah Celsius sejak beberapa juta tahun yang lampau. Rekod suhu sejak 30 hingga 50 tahun yang lalu menunjukkan trend yang meningkat di kebanyakan tempat termasuk Malaysia. Perubahan iklim mungkin menyebabkan peningkatan kekerapan dan intensiti kejadian-kejadian cuaca yang melampau seperti kemarau, ribut dan banjir. Terdapat banyak akibat perubahan iklim global dan ianya adalah amat pelbagai. Perubahan iklim adalah disebabkan oleh penghasilan gas yang memerangkap haba – kebanyakannya karbon dioksida (CO₂) – daripada kenderaan, industri, stesen janakuasa dan penyahhutan. Peningkatan gas tersebut bertindak sebagai selimut tebal yang menyebabkan kepanasan melampau terhadap bumi,

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menrubah iklim, dan mengancam kesihatan, ekonomi dan alam sekitar. Analisis rekod suhu di Malaysia menunjukkan trend kepanasan yang meningkat. Perubahan suhu di Malaysia terdapat di antara +0.7°C kepada 2.6°C, sementara perubahan kerpasan terdapat antara -30% hingga +30%. Perubahan iklim di Malaysia menunjukkan bahawa fenomena tersebut mempunyai impak negatif terhadap habitat manusia seperti pertanian, hutan, sumber air, sumber pinggir pantai, kesihatan dan sektor tenaga.

INTRODUCTION

Climate change is considered to be one of the biggest threats facing nature and humanity today. It is an undeniable, pervasive, and insidious planetary crisis that affects every aspect of our lives and future. Climate change, as defined by the United Nations Framework Convention on Climate Change (UNFCCC), is a change of climate which is attributed, directly or indirectly, to human activity which changes the composition of the global atmosphere and is in addition to natural climate variability observed over comparable time periods.

Climate refers to the representative or characteristic atmospheric conditions for a region on Earth. The term climate refers to these conditions over long time periods, such as seasons, years, or decades. Climate depends in part on precipitation and temperature, both of which show tremendous variability on a global scale (Botkin & Keller 2005). Climate is important, not only because they affect human activities, but because they are primary determinants of biomes and ecosystem distribution.

Climate change is any long-term significant change in the “average weather” that a given region experiences. Average weather may include average temperature, precipitation and wind patterns. It involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years (Wikipedia 2008). These changes can be caused by dynamic process on Earth, external forces including variations in sunlight intensity, and more recently by human activities. In detailed, Climate Change means annual temperature of the Earth has swung up and down by several degrees Celsius over the past million years. Temperature records in the past 30 to 50 years have shown warming trends in most places including Malaysia.

The global mean surface temperature in the last decade has been the warmest since instrumental records began in 1860. Warming since the mid-1970s has been approximately three times as rapid as in the

preceding 100 years (Botkin & Keller 2005). The 1990s were the warmest decade in the 142 years since temperatures have been recorded, and in the last 1,000 years, according to geologic data. The global mean surface temperature in 1998 exceeded that of 1997 and is the highest on record since 1860. The warming has not, however, been uniform globally, with some areas recording cooling in recent decades. Climate Change may bring about an increase in the frequency and intensity of extreme weather events, such as, droughts, storms and floods.

For example, in 2003, Europe experienced summer heat waves, with the warmest seasonal temperatures ever recorded in Spain, France, Switzerland, and Germany. Approximately 15,000 people died in heat waves in Paris during the summer. Furthermore, warm conditions with drought contributed to severe wildfires in Australia, southern California, and British Columbia (Botkin & Keller 2005).

Intergovernmental Panel of Climate Change (IPCC) (1995) projects an increase in temperature, relative to the present, of between 1°C and 4.5°C by the year 2100. When the effect of aerosols is included, a lower range of global temperature change of 1°C to 3.5°C is projected. The Global Climate Change Models (GCMs) also project higher global precipitation under increased Greenhouse Gas (GHG) concentrations. The increase is largest in the high latitudes during winter, very often extending into the mid-latitudes. The precipitation pattern in the tropics, however differ between models, and there are shifts and changes in the rainfall maxima.

THE CAUSES OF GLOBAL CLIMATE CHANGE

There are many factors identified to cause and influence climate change. These factors could be global, national and localized factors. Global warming, open burning (haze) are some of the good examples of global factor that are trans-border in nature whilst industrialization, clearing of land for agriculture, encroachment of fragile ecosystem are examples of national and localized causal factors.

The Intergovernmental Panel on Climate Change (IPCC) has declared that human activity is the main force behind global warming. In its recently released Fourth Assessment Report, the IPCC stated that continued climate change could result in more extreme and often more dangerous weather phenomenon like heat waves, droughts, heavy rains, and intense cyclonic storms.

Human activities such as transportation and industrializing are releasing and accumulating green house gases such as carbon dioxide

(CO₂) and certain other trace gases including methane (CH₄), nitrous oxide (N₂O), chlorofluorocarbons (CFCs), and tropospheric ozone (O₃) in the atmosphere. For example, the concentration of atmospheric carbon dioxide has increased from about 288 parts per million (ppm) approximately 200 years ago (before Industrial Revolution began) to 376 ppm in 2003. Burning carbon-containing fossil fuels such as coal, oil, and natural gas accounts for most human-made carbon dioxide. Land conversion, such as when tracts of forests are logged or burned, releases CO₂. Scientists estimate that the concentration of atmospheric CO₂ in 2050 will be double what it was in the 1700s (Raven & Berg 2005).

The levels of other trace gases associated with global climate change are also rising. The combustion of gasoline in the car's engine releases not only CO₂ but also nitrous oxide and triggers the production of tropospheric ozone. CFCs, relate to depletion of the stratospheric ozone layer, are refrigerants released into the atmosphere from old, leaking refrigerators and air conditioners.

Decomposition of carbon-containing organic material by anaerobic bacteria in moist places as varied as rice paddies, sanitary landfills, and the intestinal tracts of cattle and other large animals (human included) is a major source of methane. Water vapor is a greenhouse gas, and it has a positive feedback on the climate that may amplify warming; warmer air temperatures cause greater evaporation from the ocean, which in turn causes warmer air temperatures.

Global climate change occurs because these gases absorb infrared radiation where can heat the atmosphere. This absorption slows the natural heat flow into space, warming the lower atmosphere. Some of the heat from the lower atmosphere is transferred to the ocean and raises its temperature as well. This retention of heat in the atmosphere is a natural phenomenon that has made earth habitat for its million of species. However, as human activities increases the atmospheric concentration of these gases, the atmosphere and ocean may continue to warm and the overall global temperature may rise (Raven & Berg 2005).

Other Pollutants Cool the Atmosphere. One of the complications that makes the rate extent of global climate change difficult to predict is that other air pollutants, known as atmospheric aerosol, tends to cool the atmosphere. Aerosols, which come from both natural and human sources, are tiny particles so small they remain suspended in the atmosphere for days, week, or even months. Sulfur haze in an aerosol that cools the planet by reflecting sunlight back into space, away from Earth. This aerosol effect reduces the amount of solar energy that reaches Earth's surface, thereby cooling the atmosphere.

Climate scientists have evidence that sulfur haze significantly moderates warming in industrialized parts of the world. Sulfur emissions that produce sulfur haze come from the same smokestacks that pour forth carbon dioxide. In addition, volcanic eruptions inject sulfur-containing particles into the atmosphere. Because sulfur in the stratosphere reduces the amount of sunlight that reaches the planet, this eruption caused Earth to enter a temporary period of global cooling (Raven & Berg 2005).

THE MAIN EFFECTS OF GLOBAL CLIMATE CHANGE TO HUMAN HABITAT AND ENVIRONMENT IN MALAYSIA

Climate change is a global issue and will be felt in all corners of the world. An analysis of temperature records in Malaysia shows a warming trend. In Malaysia, forecast have been made on climate modeling using 14 GCM's (Global Climate Models) which shows that Malaysia could experience temperature changes from 0.7 to 2.6 degree Celsius and precipitation changes ranging from -30% to 30% (Ministry of Science, Technology and the Environment 2000).

In general, Malaysia could be considered as a free zone from climate related disaster. However, mild climate related disasters are quite frequent to happen lately. These refer to the occurrence of floods and droughts that caused significant socio-economic impacts to the nation while the occurrence of landslides due to excessive rainfall and strong winds happened at the hilly and the latter, at the coastal areas caused minimal damage. The potential impacts of climate change in the Malaysian context would include sea level rise, reduced crop yields, greater diseases among forest species and biodiversity loss, erosion of shorelines, increased flood intensities, coral reef bleaching, increased incidences of disease, tidal inundation of coastal areas, decreased water availability, loss of biodiversity, and more droughts, among other things.

By 2050, projections show that Malaysia's going to be hotter with a temperature rise of up to 1.5°C. We also expect more rainfall extremes—intense rainfall in the wet period and a lack of rainfall in the dry period. This would lead to higher high flows, meaning more severe floods, and lower low flows, meaning longer droughts. Sea level is also expected to rise anywhere from 15 to 95 centimeters over a hundred-year period, threatening the increasing urban population in our coastal areas (<http://www.adb.org/water/champions/zakaria.asp>). In fact, the rapidly changing weather patterns and climate variability in the region and in the country proper have already seen Malaysians suffer from recent major

flood events in December 2006 and January 2007 which badly affected the southern state of Johore in Peninsular Malaysia.

Agriculture

Agriculture is one of the sectors greatly affected by extreme climate change. Agriculture in Malaysia contributes about 3.6% of GNP and at least one third of the country's population depends to the agriculture sector for their livelihood, with some 14% working in farms and plantations. From the land use perspective, about 39.2% of total land use or about 5.18 million hectares are planted with tree crops like rubber, oil palm, cocoa, coconut, fruits and vegetables.

Thus, significant climate change definitely affects the agriculture sector in term of production as well as the impacting socio economics problem to the people involved in the sector and the nation as a whole. Physical damage, lost of crop harvest, drop in productivity, vigor and others related to crop potentials are examples of direct and indirect effect of the extreme climate change. Thus, occurrence of disaster due extreme climate change such as floods, could impact damaging effect on the economy, social and psychology of the people affected. Recent floods in Johor had displaced 110,000 people, damaging an estimate of RM 0.35 billion worth of infrastructures and RM 2.4 billion of economics losses. An estimate of RM 84 million worth of agriculture produce were damaged or losses affecting 7000 farmers (<http://www.met.gov.my/climatechange2007/session1b/speaker>).

Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. Several factors directly connect climate change and agricultural productivity:

- ❖ Average temperature increase
- ❖ Change in rainfall amount and patterns
- ❖ Rising atmospheric concentrations of CO₂
- ❖ Pollution levels such as tropospheric ozone
- ❖ Change in climatic variability and extreme events

Climate Change plays a major role in determining crop performance. Within a climatic zone, the weather, as expressed by the amount of rainfall, sunshine hours, temperature, relative humidity and length of the drought period, results in year-to-year variability of crop production. The primary concern related to climate change is the potential threat it poses to national food security and export earnings from plantation crops. Any

unfavourable climate change can have a negative impact on crops, animal husbandry and aquaculture.

Climate change can reduce crop yield. Areas prone to drought can become marginal or unsuitable for the cultivation of some of the crops, such as rubber, oil palm, cocoa and rice, thus posing a potential threat to national food security and export earnings. As much as 6% of land planted with oil palm and 4% of land under rubber may be flooded and abandoned as a result of sea level rise.

For example, long periods of sunshine are favourable for high rice yields. Growth is optimal when the daily air temperature is between 24°C and 36°C. The difference between day and night temperatures must be minimal during flowering and grain production. An irrigation water temperature of not less than 18°C is preferred. Climate change can affect rice production in the following ways:

- ❖ Grain yields may decline by 9% to 10% for each 1°C rise in temperature.
- ❖ If drought conditions are prolonged, the current flooded rice ecosystem cannot be sustained. It may be necessary to develop non-flooded and dry land rice ecosystems to increase the level of national rice sufficiency.

Increased in temperature and changes in rainfall pattern could fasten the spread of fungus and diseases directly or indirectly (e.g. *Phytophthora* sp in rubber plantation), thus affecting yield. States that most vulnerable to these changes are the northern Peninsular Malaysia as well as the coastal of Sabah and Sarawak.

Changing climate affects the agriculture industry. Based on agricultural cycle, increasing in rainfall is not good for rubber. Rubber plantations could suffer due to lost of tapping days and crop washouts. Some crops like oil palm could flourish with higher rainfall. However, excessive rainfall is detrimental as yield is significantly affected. It was reported that flood related problems in southern Malaysia had decreased the production of crude palm oil to 1.1 million metric ton or 26.3% in December 2006 (<http://www.met.gov.my/climatechange> 2007/session 1b/speaker).

In agriculture, one of the matters that affected continuously is flood which can rapid, sudden and unexpected. The floods incidence happened in the southern states of Malaysia, involving Negeri Sembilan, Melaka, Johor and Pahang. Johor was the worst affected. It was reported that the warming effect in Siberia lead to a heavy rainfall in Southern Malaysia, compliments with poor drainage systems, thus exaggerate the floods.

Without adequate measures, occurrence of floods could cause displacement of people, damaged infrastructures and losses of agricultural production from eroded/inundated lands. In general, about 9% of the land area in Malaysia (2.97 million ha) is flood prone and as many as 3.5 million people have become victims. Monetarily, it is difficult to estimate the quantum but a conservative figure of RM 100 million has been used to estimate the average flood damage per year (<http://www.met.gov.my/climatechange2007/session1b/speaker>).

Second matter related to extreme climate change is droughts. A drought can be defined as a continuous and long period in which rainfall is significantly below the average expected for a region at that time of year. One of the well remembered but localised incidence was the 1991 drought in Malacca that caused the drying up of Durian Tunggal Dam and resulted in prolonged water rationing in most parts of the state. Sabah was perhaps the most affected state by the 1998 drought. All the Divisions suffered extremely high rainfall deficits (some as low as 90% of long term mean) for a period ranging from 4 to 9 months, affecting more than 2,797 km² and 170,000 people. About 1580 km² was engulfed in wild fire, of which more than 100 km² were agricultural lands. More than 7,200 farmers were affected with an estimated loss of about RM 7 million. A number of districts had to go for water rationing to ease off the situation. In few villages, their hill padi crops were totally wiped out prompting the authority to send in food supply to the affected areas. Similar situation was experienced in the North Eastern part of Sarawak near Miri region. The prolonged and extremely dry spells had resulted rampant wild fire that had destroyed a sizable area of agricultural crops (<http://www.met.gov.my/climatechange2007/session1b/speaker>). Meanwhile, the rising in sea level due to climate change could force the abandoning of low-lying planted areas such as paddy, corn, coconut and others.

Livestock is usually raised under shade conditions in order to avoid direct heat load from solar radiation. Air temperature, relative humidity and airflow are the main environmental factors that affect production. Since livestock are homeotherms, that is, they maintain a constant deep body temperature; heat produced must be lost to the atmosphere. A rise in air temperature would lead to heat stress being experienced by the animals. In fact, livestock – for example, cattle and broilers – would suffer heat stress, particularly during the hot periods of the day between 12 noon and 4 p.m., if temperature rises. This can lead to reduced meat production.

Forestry

The effects of climate change on forests in the world will depend not only on climatic factors but also on stresses from pollution (e.g., acid rain); future trends in forest management practices, including fire control and demand for timber; and land-use change. It is difficult to separate the influence of climate change from these other pressures. Climate change effects on forests are likely to include changes in forest health and productivity and changes in the geographic range of certain tree species. These effects can in turn alter timber production, outdoor recreational activities, water quality, wildlife and rates of carbon storage.

In general, forests are sensitive to climatic variability and change. Climatic factors that influence forest health—temperature, rainfall, atmospheric levels of carbon dioxide (CO₂) and other greenhouse gases and extreme weather and fire events—are changing and are expected to continue changing due to human activities. The following climate factors are likely to play an important role in determining future forest conditions (IPCC 2007):

- ❖ Air temperature
- ❖ Precipitation amount and seasonal distribution
- ❖ Atmospheric CO₂ concentrations
- ❖ Frequency and severity of wildfire events
- ❖ Climatic variability and the frequency and severity of extreme events
- ❖ Indirect effects on pollution levels such as tropospheric ozone

There are two important aspects to consider in assessing the impact of climate change on forests. First, forests form an essential component of the global carbon cycle, acting as a reservoir for storing carbon. Second, the forest ecosystem is an integral part of the biological system, constantly reacting to variations in climate. The forest's response to climate change is biologically complex. The effects are not quickly observed.

Forests, however, are more vulnerable to land use than to climate change. Upland forest can be expected to expand by 5% to 8% but this could be nullified by a loss of between 15% and 20% of mangrove forests located along the coast as a result of sea level rise. Disease infestation on forest plantation species may be aggravated by climate change.

Ecosystems and Biodiversity

An ecosystem is an interdependent, functioning system of plants, animals and microorganisms. An ecosystem can be as large as the Sahara Desert, or as small as a local pond. Without the support of the other organisms within their own ecosystem, life forms would not survive, much less thrive. Such support requires that predators and prey, fire and water, food and shelter, clean air and open space remain in balance with each other and with the environment around them.

Climate is an integral part of ecosystems and organisms have adapted to their regional climate over time. Climate change is a factor that has the potential to alter ecosystems and the many resources and services they provide to each other and to society. Human societies depend on ecosystems for the natural, cultural, spiritual, recreational and aesthetic resources they provide. Observations of ecosystem impacts are difficult to use in future projections because of the complexities involved in human/nature interactions (e.g., land use change). Nevertheless, the observed changes are compelling examples of how rising temperatures can affect the natural world and raise questions of how vulnerable populations will adapt to direct and indirect effects associated with climate change.

In various regions across the world, some high-altitude and high-latitude ecosystems have already been affected by changes in climate. The Intergovernmental Panel on Climate Change reviewed relevant published studies of biological systems and concluded that 20 percent to 30 percent of species assessed may be at risk of extinction from climate change impacts within this century if global mean temperatures exceed 2-3 °C relative to pre-industrial levels (IPCC 2007). The impact of climate change on Malaysia's rich biodiversity is also of great concern, where, with the intricate interrelationships between plant and animal species, the impact on any one species can have consequences for other species as well.

Land and Recreational Areas

National Parks, National Wildlife Refuges, and other protected areas harbor unique environments and wildlife not found elsewhere. This raises particular concerns about the vulnerability of these ecosystems to a changing climate. Many parks and refuges are designated to protect rare natural features or particular species of plants and animals. Changes in

climate could create new stresses on natural communities, and, in the absence of adaptation, lead to the loss of valued resources.

Outdoor recreation and tourism are sensitive to changes in temperature, rainfall, snowfall, and storm events, and are thus sensitive to climatic variability and change. Tourism businesses, which usually are location-specific, have a lower potential than tourists themselves (who have a wide variety of options) to adapt to climate change. Shifts in temperature and precipitation patterns could lead to shifts in a variety of outdoor tourism and recreation opportunities, such as fishing and hunting. The effects of climate change on tourism in any particular area however depend on seasons and tourist activities. For example, Shifts in migratory bird populations may affect recreational opportunities for birdwatchers, wildlife enthusiasts and hunters and anglers. At the same time, coastal regions face the possibility of land loss due to sea-level rise. Replenishing beach sands may become a more extensive and costlier effort. In addition, the tourism industry related to snorkeling and scuba diving may be negatively affected by changes in coral reefs.

Water Resources and Water Availability

All regions of the world show an overall net negative impact of climate change on water resources and freshwater ecosystems. Areas in which runoff is projected to decline are likely to face a reduction in the value of the services provided by water resources. The beneficial impacts of increased annual runoff in other areas are likely to be tempered in some areas by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks (IPCC 2007).

It has been observed that, since 1977, there have been more frequent El Nino Southern Oscillation (ENSO) warm phase episodes. This behaviour, especially the persistent warm phase from 1990 to mid-1995, was unusual in the last 120 years and significantly influenced rainfall in Malaysia. Furthermore, increasing temperatures will result in higher evapotranspiration leading to reduction in water availability. This problem will further exacerbated during the dry months. On the other hand, an increase in storm magnitudes will result in an increase in the frequency and intensity of floods and, therefore, flood damage.

Climate change will have an impact on water availability (surface runoff). For a 1⁰C increase in temperature, in general, there is an increase in the potential evapotranspiration (PET) of between 3% and 9%, that is about 90 mm additional loss of moisture on the average per annum. For a

3°C temperature increase, the PET is expected to rise to a range of 9% to 13%, which represents potentially about 170 mm of extra moisture loss.

With temperature increases of 1°C and 3°C, the reductions in long term average monthly runoff during wet months are found to be relatively low, ranging between 1% and 5% and between 2% and 17%, respectively. During the dry periods, the ranges for 1°C and 3°C scenarios are between 1% and 16% and between 1% and 24%, respectively.

In the case of a reduction in rainfall (10%) in combination with temperature rise (1°C and 3°C), the impact of rainfall reduction on runoff rates is found to be much more pronounced than that due to temperature rise. When rainfall totals are reduced by 10% across the whole time series, the corresponding decrease in runoff production reduces by an amount of between 12% and 31% during wet months. During dry months the reduction ranges from 13% to 38%. For the case of combined effects with 30C rise in temperature, the reductions in runoff ranges from 13% to 48% and from 17% to 53% during wet and dry months, respectively. Given the likely significant reductions in surface runoff as a result of climate change, the nation's water resources have to be carefully managed. In particular, storage capacities by dams and reservoirs must be developed to ensure the steady supply of water through a prolonged period of dryness.

Water shortage would severely affect agricultural yield if the storage supply is insufficient to weather a prolonged drought. Wetland paddy, the principle source of the nation's supply, is particularly sensitive to the problem. The off-season paddy crop is entirely dependent on irrigation. Other forms of cultivation as well as competing needs by industry and households will place further strain on the available water supply. During dry spells the low rate of runoff will also lead to deterioration in river water quality. Apart from presenting itself as a problem to the water authority, there is the more immediate threat to aquatic life as a result of water quality degradation in rivers.

Coastal Zones and Sea Level Rise

Coastal zones are particularly vulnerable to climate variability and change. Key concerns include sea level rise, land loss, changes in maritime storms and flooding, responses to sea level rise and implications for water resources. Sea level is rising around the world. In the last century, sea level rose 5 to 6 inches more than the global average along the Mid-Atlantic and Gulf Coasts, because coastal lands there are subsiding. Higher temperatures are expected to further raise sea level by

expanding ocean water, melting mountain glaciers and small ice caps, and causing portions of Greenland and the Antarctic ice sheets to melt. The IPCC estimates that the global average sea level will rise between 0.6 and 2 feet (0.18 to 0.59 meters) in the next century (IPCC 2007).

Rising sea level increases the salinity of both surface water and ground water through salt water intrusion. If sea level rise pushes salty water upstream, then the existing water intakes might draw on salty water during dry periods. Salinity increases in estuaries also can harm aquatic plants and animals that do not tolerate high salinity. Rising sea levels inundate wetlands and other low-lying lands, erode beaches, intensify flooding, and increase the salinity of rivers, bays, and groundwater tables. Some of these effects may be further compounded by other effects of a changing climate. Additionally, measures that people take to protect private property from rising sea level may have adverse effects on the environment and on public uses of beaches and waterways.

The impact on coastal resources in Malaysia can be classified into four broad categories. The first is tidal inundation, where about 1200 km² in Peninsular Malaysia alone will be submerged subsequent to bund failure, and mangroves will be lost if sea level rises at a rate of 0.9 cm/year. The second is shoreline retreat. The third is increased wave action which can affect the structural integrity of coastal facilities and installations such as power plants. The last is saline intrusion, which can pose a potential threat of water contamination at water abstraction points. Examples of other impacts include submerged of corals, coral bleaching due to increasing levels of CO₂ in the water, and depletion of fisheries resources due to loss of mangrove habitats.

Erosion and Sedimentation

Average annual soil expressed in tones per km² per year for Peninsular Malaysia, Sabah and Sarawak is 355, 518 and 1,524, respectively. These differences in sediment load are primarily caused by the differences in land use practices. Studies on erosion and sedimentation rates indicate that a large proportion of the total annual loss is produced during a few large storms. Consequently, there will be a higher risk of slope failures of riverbanks and hills, faster rate of sedimentation of reservoirs and channels, and more extensive loss of soil nutrients. For instance, in the Kelantan River, an increase of river discharge by 20% would cause a sediment load increase of 33%. In Sabah and Sarawak, an increase of 20% in high flow magnitudes and frequencies will translate to a 44% surge in sedimentation loads.

Health

Climate change is also expected to cause adverse health consequences. Human beings are exposed to climate change through changing weather patterns (for example, more intense and frequent extreme events) and indirectly through changes in water, air, food quality and quantity, ecosystems, agriculture, and economy. At this early stage the effects are small but are projected to progressively increase in all countries and regions. A direct impact could be deaths due to heat stress or respiratory diseases due to air pollution, while indirect effects could include increased food and water-borne diseases, resulting from changes in rainfall pattern. An Institute for Medical Research (IMR) model shows that high rainfall is required for high transmission of dengue.

There could be an increase in vector-borne disease – such as malaria and dengue fever – as changes in temperature will increase the availability of suitable breeding habitats for the vectors. For example, in 2007 Malaysia recorded 30,285 dengue cases with 65 deaths, up from 20,258 cases and 49 deaths in the first seven months of 2006. The bulk of the cases were in the states of Selangor, Kelantan, Johor and Kuala Lumpur. Climate change would have a direct effect on vector distribution and consequently in diseases, such as, dengue, malaria, filariasis and Japanese encephalitis (JE).

Water-borne diseases are also concentrated in the tropical and subtropical regions of the world. Food and water-borne diseases are due to indirect health effects of a changing climate. These include: (i) diarrhoeal diseases caused by a variety of organisms (such as, *Escherichia coli*., *Vibrio cholera*, *salmonellae* and viruses), (ii) other viral diseases (such as, hepatitis A and poliomyelitis) and (iii) protozoan diseases (such as giardiasis and amoebic dysentery). Climate and seasonality are important determinants in the incidence of air-borne diseases, such as, asthma, and other respiratory infections.

Electricity Production and Consumption

Climate change will have adverse impacts on electricity production and consumption, and the oil and gas industries. Sea level rise is a major concern to electrical power producers because most of their thermal power plants are located near the sea to water cool plants. Infrastructure for energy production, transmission and distribution could be affected by climate change. For example, if a warmer climate is characterized by more extreme weather events such as windstorms, ice storms, floods,

tornadoes and hail, the transmission systems of electric utilities may experience a higher rate of failure, with attendant costs (IPCC 2007). Operational and maintenance costs of electricity producers will be substantially increased to provide the necessary protection for power plants located along the coasts due to increased coastal erosion. For example, the Paka Power Station in Terengganu is experiencing the effects of severe coastal erosion and has to be defended by costly structural works (such as concrete sea walls).

A rise in air and water temperature will reduce plant efficiency and power output leading to higher production costs. With the rise in sea level rise, the splash zone for offshore facilities of all the power plants requires extra painting and cathodic protection. The potential increase in the occurrence of severe tropical storms will escalate operational and maintenance costs of electricity producers.

There will also be an increase in the consumption of electricity if there is a rise in the air temperature, as it would result in an increased use of air-conditioning. Oil and gas industries and associated coastal facilities will be similarly affected. The projected increase of 20c to 40C in the mean temperature will be a major factor in the increased use of electricity. The increase in ambient temperature will prompt the public to use more electrical energy to cool themselves by increasing the use of fans and air conditioning.

CONCLUSION

Climate change is already beginning to transform life on Earth including Malaysia. Around the globe, seasons are shifting, temperatures are climbing and sea levels are rising. Climate change does not happen by default. It is a man-made problem. Every bit of coal, every litre of oil or gas that humans burn adds to the load of gases in the atmosphere that engulf the planet like an ever thicker blanket, trapping heat, smothering people and nature. As green house gases build up, they act like a thick blanket, overheating the planet, changing our climate, and threatening our health, economy and natural environment.

A disaster caused by climate change could be defined as a serious disruption to the functioning of a community or a society causes widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. Around the world, 3 billion people who live in poverty around the world will be hardest hit by climate change. The poor are more dependent on natural resources and have less of an ability to adapt

to a changing climate. Diseases, declining crop yields and natural disasters are just a few of the impacts of climate change that could devastate the world's most vulnerable communities.

Climate change is appropriately considered a more difficult problem to solve. For that reason, Malaysia adopts 'precautionary principles' to mitigate and adapt to climate change, even though there are still scientific uncertainties. At the national level, Malaysia has formed a National Climate Committee to formulate and implement strategies on climate change. The strategies drawn include policies on energy usage, public awareness on climate change, food supply and effective forest and coastal management to mitigate deforestation and the rising of sea level.

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